(2)

NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 3-89

BRITISH SCUBA FULL FACE MASK EVALUATION FOR USE WITH SCUBA IN COLD WATER/CONTAMINATED WATER

F. J. STANLEY

MARCH 1989

NAVY EXPERIMENTAL DIVING UNIT

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

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NAVY EXPERIMENTAL DIVING UNIT

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F. J. STANLEY

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AD #

Submitted:

F.J. STANLEY
CPO(D), RN
Task Leader

Reviewed:

M.T. WALLICK
LCDR, MSC, USN
Task Advisor

H.J.C. SCHWARTZ
CAPT, MC, USN
Senior Medical Officer

H.L. PRUITT
LCDR, USN
Senior Projects Officer

J.B. McDONELL
LCDR, USN
Executive Officer

Approved:

JAMES E. HALWACHS
CDR, USN
Commanding Officer

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A comparison of three SCUBA full face masks (FFM) was conducted to recommend a FFM to be included on the Diving Equipment Authorized for Navy Use (ANU) list. After assessing the peripheral vision provided by the three masks and evaluating their performance during dives in open water and cold water, two of the three masks were found to meet the requirements. These were the British FFM and the Parkway Cressi Sub FFM. Both are recommended for inclusion on the ANU list. The third mask the Birns Oceanographics U.S. Divers Aqualung FFM was not recommended for ANU.

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I. INTRODUCTION

The Navy Experimental Diving Unit (NEDU) was tasked to evaluate the British SCUBA Full Face Mask (FFM) for inclusion on the Diving Equipment Authorized for Navy Use (ANU) list for use with SCUBA when diving in cold water, and if feasible in contaminated water.[1] It was decided to evaluate the mask by making a comparison with other FFMs intended for use in conjunction with Navy in-service regulators and available on the open market. Two other masks were identified and purchased. They were a Parkway Cressi Sub FFM and a Birns Oceanographics U.S. Divers Aqualung FFM. Each mask was evaluated in three stages, (a) cold water, (b) open water SCUBA dives, and (c) a peripheral vision test. To complete this evaluation, the test plan of Appendix A was developed. Special attention was given to any ingress of water to the masks when wearing hoods to evaluate their suitability for possible use in contaminated water.

Throughout the text each mask is referred to as follows:

a. British SCUBA FFM.

b. Parkway Cressi Sub FFM.

c. Birns Oceanographics U.S. Divers Aqualung FFM.

II. DESCRIPTION OF MASKS

A. BRITISH SCUBA FFM

The British SCUBA FFM is already used by the Royal Navy. This mask has a NATO stock number as do the spider bands, mouthpieces, and nose clips. Stock numbers are as follows:

Mask	4220 99 525 5331
Spider	4220 99 431 7574
Mouthpiece	4220 99 431 7530
Nose Clip	4220 99 531 1781
Nose Clip (nonmagnetic)	4220 99 431 7512

This mask is also available for supply from Hopkins Ltd., a United Kingdom (UK) based firm, through Mr. Gene Burcher, 4116 North Garland Street, Alexandria, Virginia 22304, telephone 703-370-6589.

The mask can be used with appropriate mouthpiece fittings in conjunction with various types of breathing apparatus. The mask is made of rubber and has a wide-vision perspex visor riveted and sealed into the front of the mask. The mask is held against the face by a fabricated rubber spider band having six straps, each of which reeves through a clip on the edge of the mask, each clip being fitted with a release tag. An inturned rubber sleeve in the front of the mask takes the regulator and mouthpiece assembly, which is then bound into the sleeve.

To make the mouthpiece assembly fit onto a regulator, a gasket made from a standard mouthpiece must first be inserted inside the supplied mouthpiece and glued. The whole assembly when fastened by the usual method is then secure and watertight.

The mask is made tight against the wearer's face by a water seal comprising a thin rubber duct bonded around the inside of the mask and completely filled with distilled water through a spigot in the left-hand side of the mask. After filling, the spigot is closed by means of a tufnol plug, bound with flax thread. The water seal is filled and plugged by the manufacturers and should not normally be interfered with. The water filling makes a pliable seal which, when subjected to external water pressure, adapts itself to the shape of the wearer's face.

B. PARKWAY CRESSI SUB FFM

The Parkway Cressi Sub FFM has a very basic design based on a regular swim mask, with the seal extended below the chin and an orifice for the fitting of a regulator. Its spider band is three legged with the middle strap securing top center and joined to two side straps. The regulator and mouthpiece assembly is bound through the molded mouth sleeve on the mask forming a watertight seal between regulator and mask. The mask is available for purchase through Parkway (a diving supply company), Marvel catalog #700601.

C. BIRNS OCEANOGRAPHICS U.S. DIVERS AQUALUNG FFM

The Birns Oceanographics U.S. Divers Aqualung FFM (distributed by Birns Oceanographics, Inc.) is also based on a regular swim mask which has its seal extended to below the chin. A one way water dump valve is fitted in the lower portion of the glass. The face seal is below the nose with a sealed compartment below that is just for the mouth; a mouthpiece is not required. The mask is so designed that the user must either make the hole for a single hose regulator or, by using the two fixtures molded on the sides, for a double hose regulator. The mask is held to the face with a five legged spider.

III. TEST PROCEDURE

Each FFM used was fitted with an in-service SCUBA single hose regulator. All diving was conducted with each diver using conventional SCUBA equipment. Two weeks of open water diving were conducted. A questionnaire was answered by each diver on completion of each dive and a final dive questionnaire upon completion of all dives. Each mask was also used by the cold water dive team during their work up dives. A peripheral vision test of each mask was also conducted.

A. OPEN WATER DIVES

For the open water dives NEDU's dive boat took the six man dive team to various dive sites in the Gulf of Mexico. All dives were conducted per the U.S. Navy Diving Manual and maximum depths were within the no decompression

table limits. Ideal endurances of between 30-40 minutes were attempted. Although it was intended to use the same six divers throughout the 2 week period as per Appendix A, manpower constraints meant that some substitutes were required during this period. To obtain uniformity in questionnaire completion the order in which each diver used all masks in this study was counterbalanced and assigned prior to beginning the open water dives. The substitutes were also given the masks in sequence so that continuity in evaluation could be maintained.

B. COLD WATER DIVES

Cold water dives were conducted in the NEDU test pool. Each mask was rigged with conventional SCUBA gear and worn with the cold water dive team's custom-fitted full dry suits. Mask-use order was counterbalanced across the divers. The water temperature was 50°F - 35°F. Each dive was for a duration of 20-40 minutes. Each diver completed the questionnaire after his dive.

Particular attention was paid to any water ingress while wearing hoods because of the interest in using these masks in contaminated waters.

C. PERIPHERAL VISION STUDY

Six divers participated in the peripheral vision assessment of each of the three masks. The evaluation order of the masks was counterbalanced across the divers. This ensured that any change in diver performance on this test over repeated trials would not be confounded with mask type. Testing was performed using NEDU's visual perimetry test equipment in the NEDU test pool. An illustration of this apparatus is shown in Figure 1. It consists of a 180° arc, 39 inches in diameter, mounted on a support frame.

The midpoint of the arc is attached to a rotating sleeve which allows the arc to be moved in 30° increments around a horizontal axis. The arc is placed in the horizontal plane and the diver is positioned so that his eyes lie on an imaginary line connecting the two 90° points at each end of the arc. A rubber-tipped support rod which extends along the center of the plane of the arc is then adjusted to rest against the center of the faceplate. Thus, the diver is stabilized both horizontally and vertically in the perimetry device and this head position is maintained throughout the testing session.

The diver's visual perimeter was measured using the "method of limits." The diver was instructed to keep both eyes open and focused straight ahead while the measurements were being taken. Beginning near the center of the perimeter arc, where the diver can clearly see it, the target pointer was slowly moved away from the midpoint along the outside edge of the arc towards its end and the diver signalled when the pointer departed from view. The pointer was then moved from a position near the end of the arc back toward its midpoint until the diver signalled that it had reentered the field of view. These ascending and descending limit measures were recorded and later averaged to produce the diver's perimetry measure for that angular position. Since the arc is marked in 5° increments, the measurement recorded required some interpolation by the experimenter.

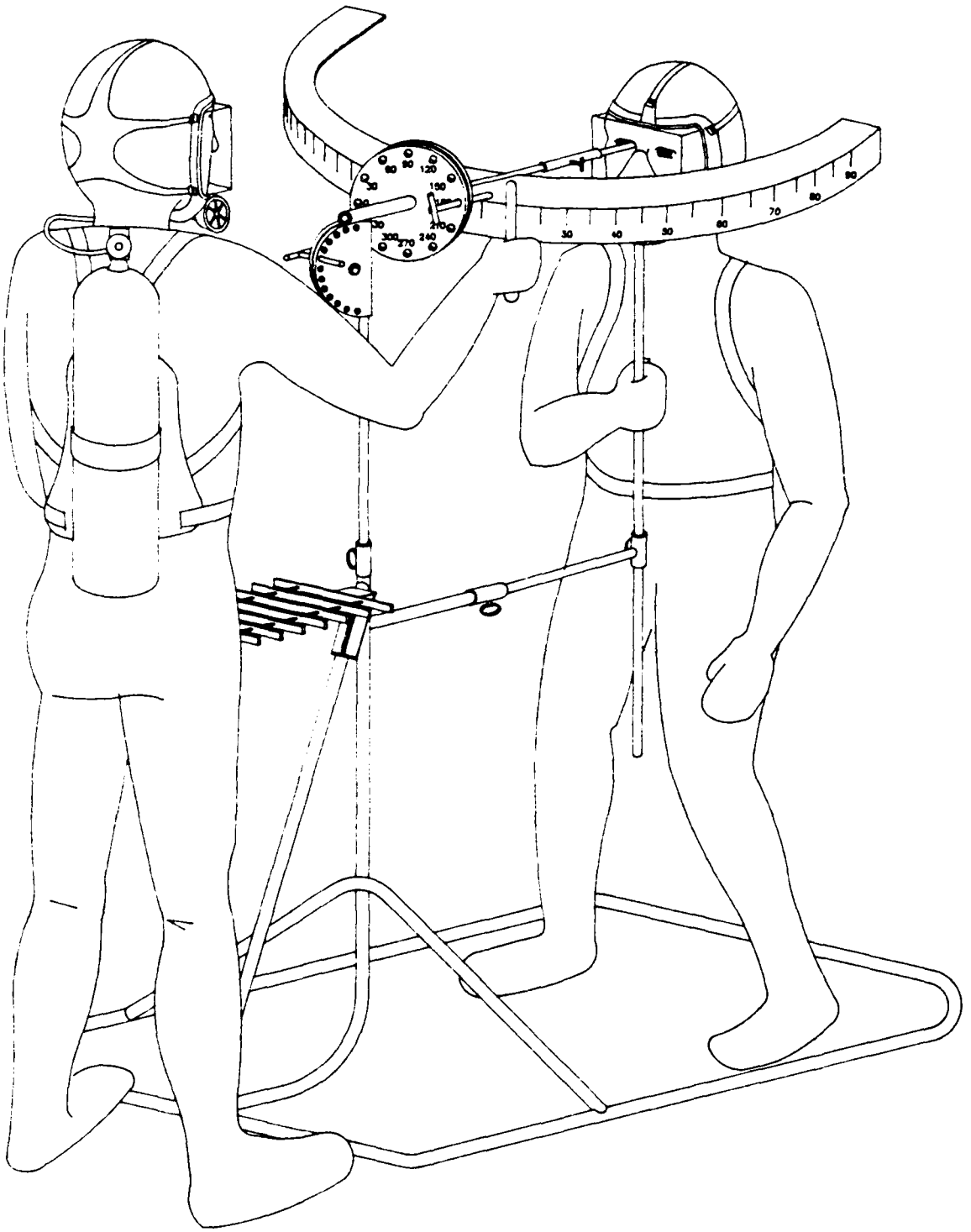

Figure 1. Underwater Visual Perimetry Device

To begin the measurement the arc was placed in the horizontal plane and the first measurement was taken on the diver's left side at 180° and then on the right side at 0°. The process was repeated, rotating the arc counterclockwise with respect to the diver-subject. Measurements were taken at 30° increments until the entire 360° perimeter was completed. Following the measurements at 90° and 270°, the arc was repositioned so that the pointer was always positioned above the top edge of the arc.

IV. TEST RESULTS

A. DIVER EVALUATIONS

The results of the dive team questionnaires are contained in Appendix B with the main observations of the evaluations outlined below. A total of 21 divers were involved in this project with 19 diving at least two of the three masks; of these 19 divers, 17 completed the final dive questionnaire comparing the three masks. The overall ratings for the three masks as reflected in the final dive questionnaire was (1) Parkway Cressi Sub FFM, (2) British SCUBA FFM, and (3) Birns Oceanographics U.S. Divers Aqualung FFM.

1. Parkway Cressi Sub FFM. The overall performance of the Parkway Cressi Sub FFM was rated as adequate to excellent by 15 of the 16 divers comparing it. It appeared as the first or second choice of all divers in the study. The best features of this mask were the comfort of the nose clearing device, the low volume of the mask and face seal. The main complaint was the stiff mouthpiece causing some discomfort and the difficulty in adjusting the mask straps.

2. British SCUBA FFM. The overall performance of the British SCUBA FFM was considered to be adequate to very good by 12 of the 17 divers rating this mask on the final dive questionnaire. It was the most highly rated mask for comfort of fit and ease of donning. The two primary complaints of the divers concerning this mask were the nose clip worn with this mask and the visual distortion caused by the curvature of the mask lens. The severity of the visual distortion effect experienced varied among the divers. However, of those who conducted several dives using this mask, most agreed that the distortion was not as noticeable in subsequent dives and felt that the increased peripheral vision provided by the mask offset the distortion for some dive situations.

When worn with a hood the British SCUBA FFM sealed better and had the least amount of water seepage with the Parkway Cressi Sub FFM a close second. Both masks gave good protection against the cold when used by the cold water team in 50-35°F water.

3. Birns Oceanographics U.S. Divers Aqualung FFM. The overall performance of the Birns Oceanographics U.S. Divers Aqualung FFM was rated as adequate or better by only 3 of the 17 divers comparing it. The Birns Oceanographics U.S. Divers Aqualung FFM produced many diver complaints of water ingress, discomfort when worn, and unsatisfactory spider fittings.

B. VISUAL PERIMETRY

An analysis of variance (ANOVA) was performed on the perimetry data for the three masks. Table 1 contains the ANOVA results and the average visual perimetry measures for each of the masks tested. Figures 2 through 4 contain graphical representations of the perimetry data plotted with the normal binocular peripheral vision curve. No significant differences were found among the three masks for peripheral vision in the upper and lower mask quadrants. Peripheral vision was significantly different in the left and right mask quadrants for the three masks ($p \leq .01$), with the British SCUBA FFM providing improved vision to the sides. A multiple range test using the Tukey-HSD procedure showed no significant difference at the p=.05 level between the remaining two masks in the peripheral vision they provided.

V. DISCUSSION

In evaluating the British SCUBA FFM it became clear that the Parkway Cressi Sub FFM was meeting the same requirements as the mask assigned for evaluation. As the Parkway Cressi Sub FFM is commercially available and not at present on the ANU list, it should also be recommended for ANU to give diving teams a choice of mask type which suits their personal preference.

As with all FFMs some problems with fogging occurred and although deemed as not a problem by divers on this study, who rinsed water over the glass during their dives, it would be a problem when being used in polluted or very cold water. Therefore, an approved anti-fogging solution should be available to the divers for cold water and polluted water diving.

VI. CONCLUSIONS AND RECOMMENDATIONS

The Birns Oceanographics U.S. Divers Aqualung FFM was found not to be suitable for U.S. Navy requirements.

Both the British SCUBA FFM and the Parkway Cressi Sub FFM were found to be ideally suited for use with SCUBA in cold water. These face masks when worn in conjunction with a full dry suit with hood will provide some thermal protection in cold water and prevent the cold numbing effect around the mouth which occurs when a regular swim mask is worn.

The use of the masks in contaminated water depends on the type of contaminant in the water, and medical and other expert advice should be sought before using any diving equipment in contaminated water. The U.S. Navy Diving Manual, paragraph 4.5.5 refers.[2] However, these masks could be considered for further testing for use in water polluted with sewage and other nonchemically/ nuclear hazardous water, provided a full dry suit with dry suit hood is worn. The mask must be adequately sealed and a reliable regulator with no water misting evident on inhalation correctly connected to the masks.

It is therefore recommended that both the British SCUBA FFM and the Parkway Cressi Sub FFM be included on the ANU list.

Table 1. Average Perimetry Measures in Degrees for Three SCUBA FFMs

Perimeter Angle	Mask Types: British	Parkway/ Cressi	Birns/ U.S. Divers	F Ratio
0	82	40	46	102.5424 *
30	58	42	44	8.4349 *
60	42	36	40	.9007
90	36	34	33	.7209
120	41	35	36	1.7285
150	54	38	41	53.0323 *
180	72	36	41	136.8096 *
210	71	36	36	77.3716 *
240	36	33	35	.2028
270	31	29	29	.1494
300	38	34	36	.4577
330	77	38	43	94.4860 *

* Two-tailed test, $p \leq .01$

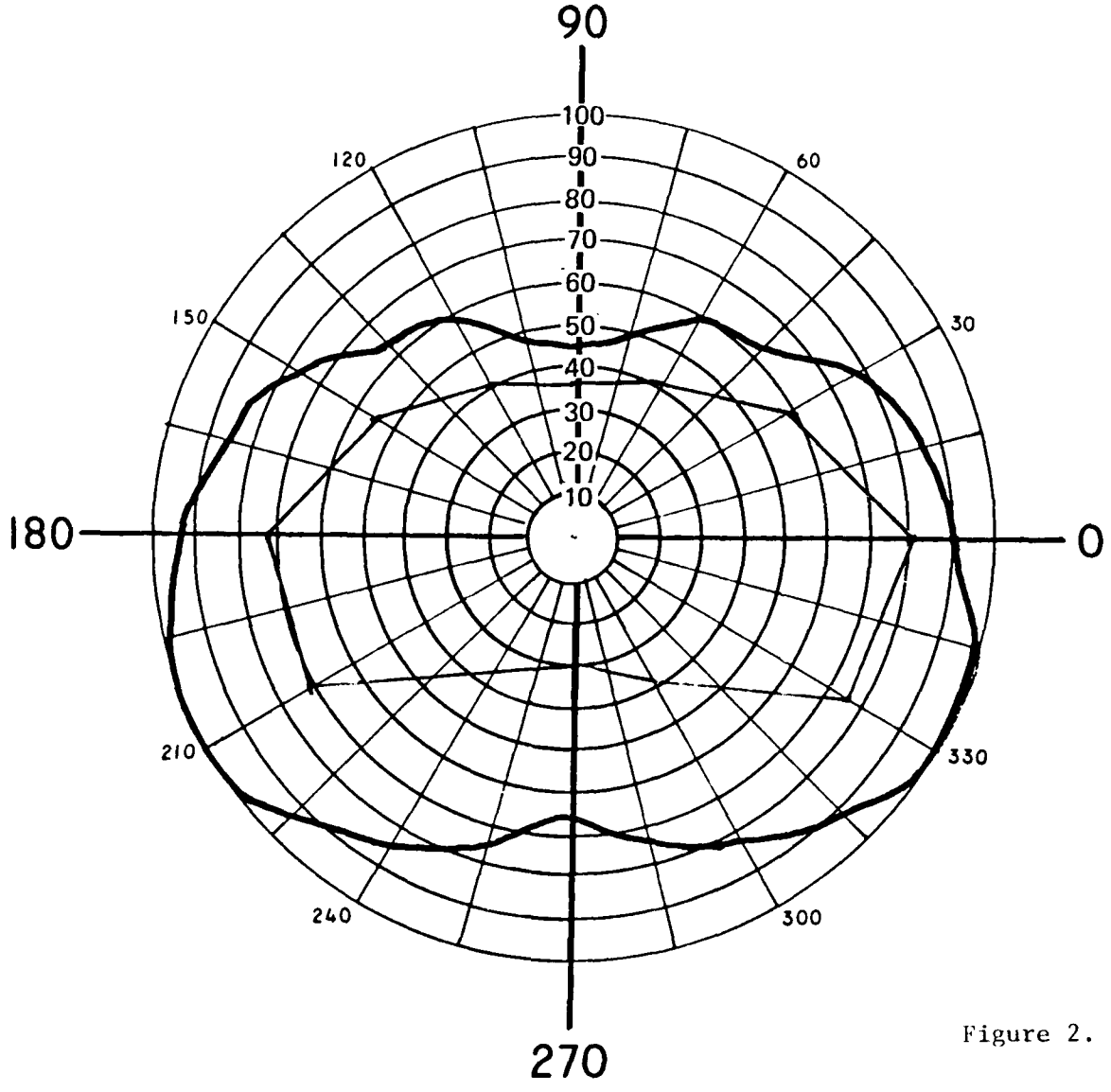

Figure 2. British SCUBA FFM Visual Perimeter

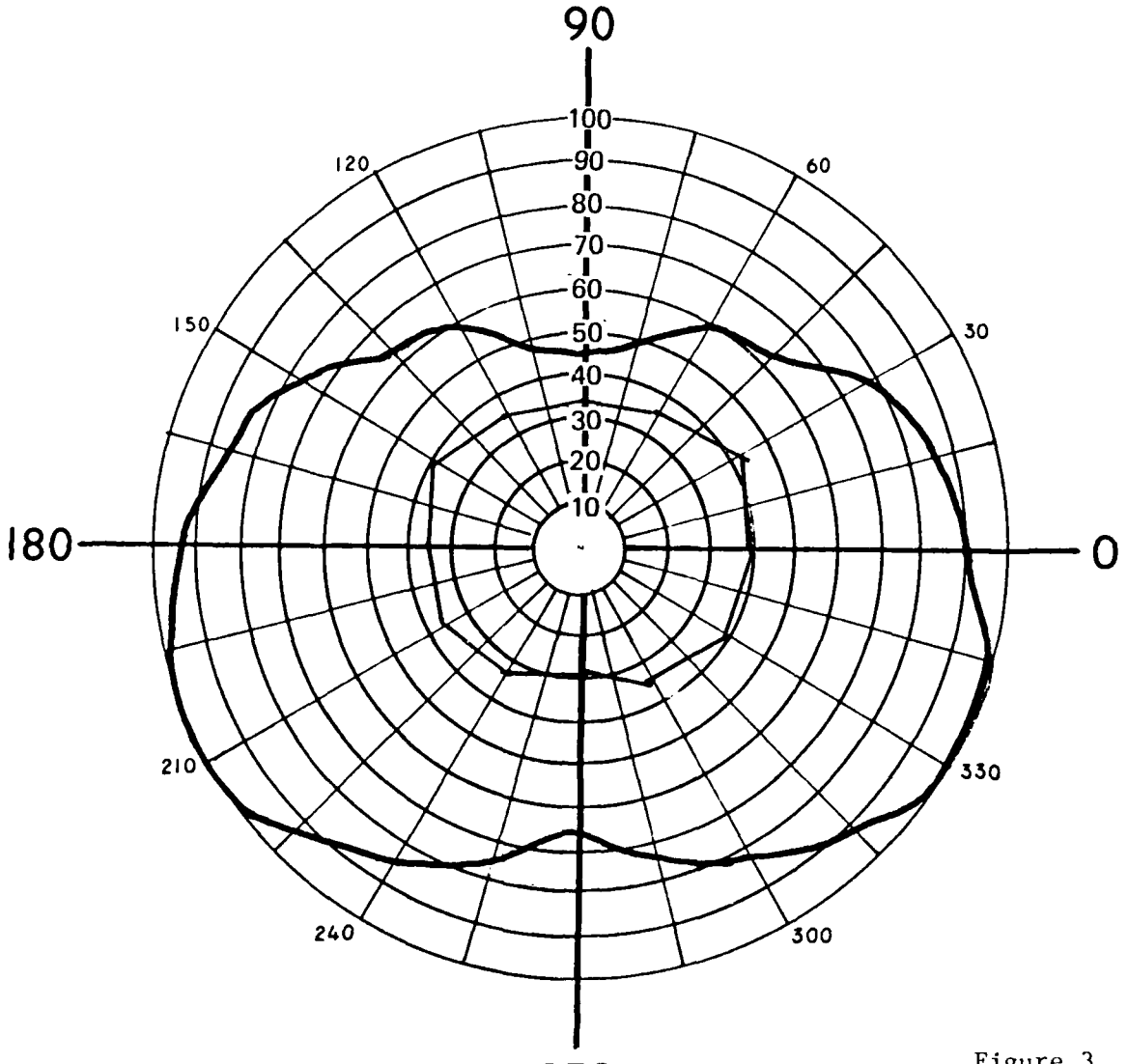

Figure 3. Parkway Cressi Sub FFM Visual Perimeter

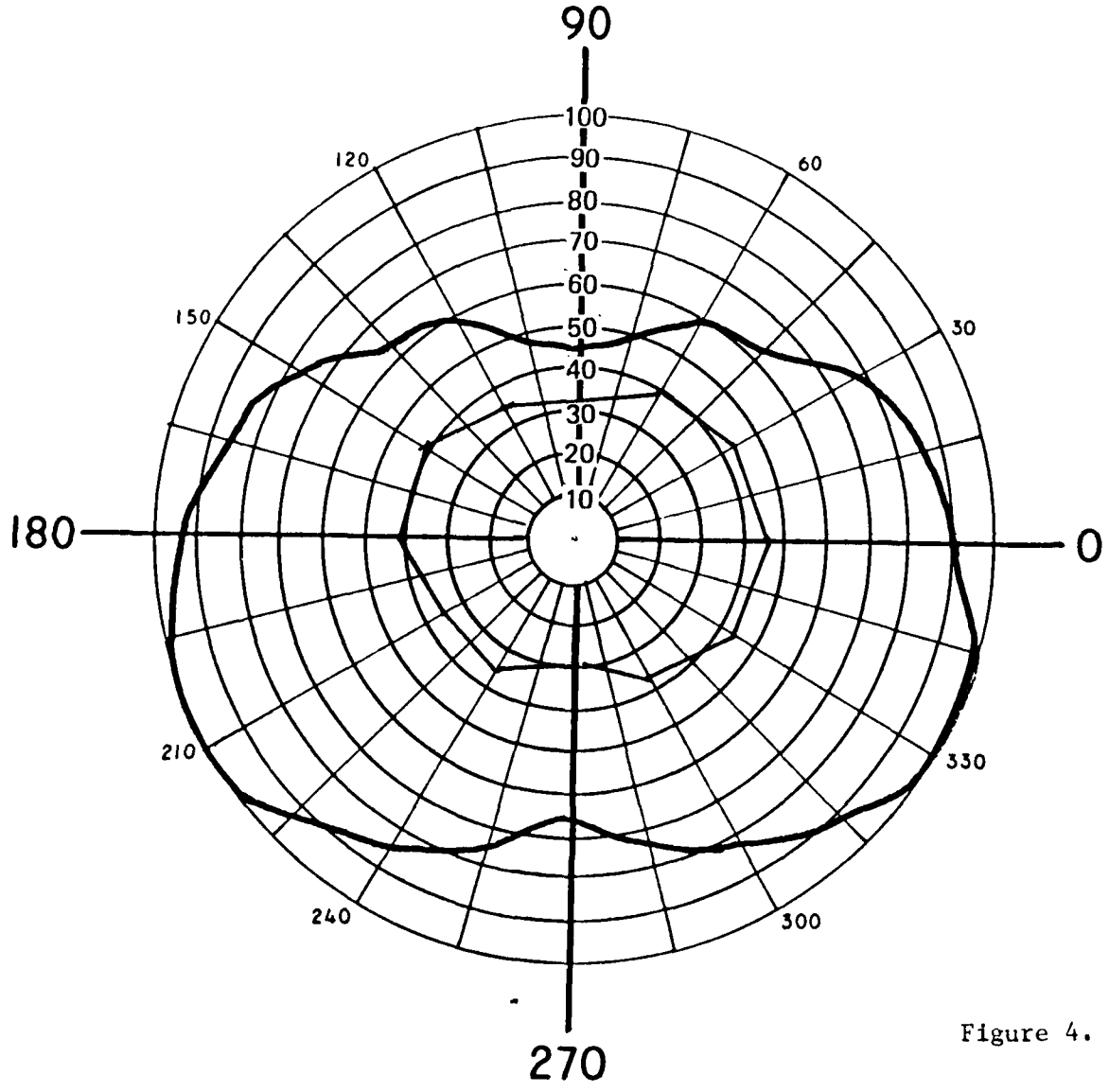

Figure 4. Birns Oceanographics Ltd FFM Visual Perimeter

REFERENCES

1. NAVSEA Task 88-58, British SCUBA FFM

2. U.S. Navy Diving Manual, Volume 1, NAVSEA 0994-LP-001-9010, Revision 1, 1 June 1985

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DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

IN REPLY REFER TO:

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STANDARD TEST PLAN

EVALUATION OF BRITISH FULL FACE MASK FOR USE WITH SCUBA

TEST PLAN NUMBER 89-06

FEBRUARY 1989

Submitted:

F.J. STANLEY
CPO(D), RN
Operations Master Diver

Reviewed:

M.T. WALLICK
LCDR, MSC, USN
Experimental Psychologist

Approved:

JAMES E. HALWACHS
CDR, USN
Commanding Officer

D.G. KIRBY
LT, CF
Operations Officer

H.J.C. SCHWARTZ
CAPT, MC, USN
Senior Medical Officer

H.L. PRUITT
LCDR, USN
Senior Projects Officer

J.C. DEVLIN
CDR, USN
Executive Officer

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References

(a) NAVSEA Task 88-58
(b) U.S. Navy Diving Manual

1. Introduction. Per reference (a) the purpose of this test is to evaluate the British Navy full face mask for use with SCUBA for cold water and contaminated water. In order to give the mask a fair evaluation it was decided to do a comparison study with other similar designs of full face mask that are readily available commercially. Two have been identified and purchased. They are the Cressi Sub full face mask distributed by Parkway and U.S. Divers Aqualung distributed by Birns Oceangraphics, Inc. At present there is only one full face mask that can be fitted to "in use SCUBA regulators" on the ANU list and this mask is no longer in manufacture. On completion of this study, it is intended to be able to recommend a full face mask for the ANU list that can be used with in service SCUBA regulators for cold water and certain types of contaminated water. Full face masks with regulators already part of mask, i.e. AGA, will not be included in this test plan.

2. Discussion. Each full face mask used will be fitted with an in service SCUBA single hose regulator. All diving will be conducted per reference (b) and each diver will be dressed using conventional SCUBA equipment. Two weeks of open water diving will be conducted. A questionnaire is to be answered by each diver on completion of each dive (ANNEX A) and a final dive questionnaire upon completion of all dives (ANNEX B). Each mask will also be used by the cold water dive team during their work up dives. A peripheral vision test of each mask will be conducted.

3. Equipment

a. For the open water dives, NEDU's dive boat will be used. All dives will be conducted with approved Navy SCUBA gear from NEDU's SCUBA Locker.

b. For the cold water team dives, the SCUBA gear will be used in conjunction with individual divers dry suits under evaluation.

c. For the peripheral vision test, the testing equipment will be made available by LCDR Wallick.

4. Personnel Requirements. For the open water and peripheral vision test, a team of six divers will be used. The cold water dives will be done in liaison with LCDR Sterba.

5. Test Procedure.

For the open water dives NEDU's dive boat will take the six man dive team to various dive sites in the gulf. All dives will be conducted per reference (b) and maximum depths will be within the no decompression table limits. Ideal endurances of between 30-40 minutes will be attempted. To obtain uniformity in questionnaire completion the order in which each diver

will use all masks in this study will be counterbalanced and assigned prior to beginning the open water dives. The following six mask-use orders will be assigned, one to each member of the dive team.

Order 1:	1	2	3
Order 2:	2	3	1
Order 3:	3	1	2
Order 4:	1	3	2
Order 5:	2	1	3
Order 6:	3	2	1

The peripheral vision test will be conducted in accordance with the procedures described in ANNEX C. The order of mask use by the divers will be the same as that for the open water portion of the study.

During the cold water dives each mask will be rigged with conventional SCUBA gear and worn with the cold water dive team's individual full dry suits. The water temperature will be 35°F - 28°F. Each dive will be for a duration of 30-40 minutes or until the air supply is exhausted. These dives will be conducted in liaison with training requirements of the cold water team. Each diver will have a facial inspection by a DMO before entering the water and immediately after each dive and intervals thereafter as decided by the DMO to ensure no cold injury of the diver's face is evident. The diver may abort his dive at any stage due to discomfort or rig malfunction. Each diver will complete the questionnaire after his dive. The order of mask use by members of the cold water dive team will depend on the number of divers available and the number of repeat dives possible within their training schedule. This will be determined prior to the start of this portion of the study and appropriate mask use-orders will be assigned.

Since mask fogging in these masks may be more of a problem than with regular SCUBA masks, standardized anti-fogging procedures will be specified for use with all masks prior to all dives. This will permit valid comparisons on this feature among the masks.

Because of the interest in using these masks in contaminated waters particular attention will be made to any water ingress while wearing hoods.

6. Safety Rules and Emergency Procedures. All dives will be conducted per reference (b). The full face mask has no extra emergency procedure. It should be noted that buddy breathing is more difficult with this type of mask and should only be used if all other rescue methods fail.

7. Termination Criteria. All dives can be terminated at any time by the dive subject due to discomfort or malfunction of the rig.

8. Report Production. A technical memorandum of evaluation results will be drafted by the Operations Master Diver.

ANNEX A

SCUBA FULL FACE MASK QUESTIONNAIRE

CIRCLE TYPE OF MASK USED:

1. British FFM 2. Parkway FFM 3. Birns Oceanographies Ltd FFM

CIRCLE TYPE OF SUIT WORN:

A. Wet Suit B. Dry Suit (specify type) _____

Did you wear gloves or mitts: ☐ YES ☐ NO (specify _____)

NAME: _____ DATE: _____

HEIGHT: _____ WEIGHT: _____ LENGTH OF DIVE: _____

WATER TEMP: _____ HOW MANY PREVIOUS DIVES WITH THIS MASK? _____

RATING CATEGORIES:

1. Extremely poor
2. Poor
3. Not quite adequate
4. Adequate
5. Very good
6. Excellent

1. How do you rate the fasteners, fittings provided on the mask? _____

   How do you rate their ease of use? _____

   How do you rate their reliability? _____

   Comments: _____

_____

2. If you wore gloves or mitts, did you have problems using or adjusting any fasteners or fittings? ☐ YES ☐ NO ☐ NOT APPLICABLE

   Comments: _____

_____

_____

RATING CATEGORIES:

1. Extremely poor	4. Adequate
2. Poor	5. Very good
3. Not quite adequate	6. Excellent

3. How do you rate?

	Fit	Comfort
Nose clip or ear clearing device:	_____	_____
Face seal:	_____	_____
Spider or strap:	_____	_____
Mouthpiece:	_____	_____

Comments: _____

_____

_____

4. What is the most uncomfortable aspect of diving this mask?

Comments: _____

_____

_____

_____

5. In your opinion do you feel that you had better thermal protection than with a regular SCUBA face mask? ☐ YES ☐ SAME ☐ NO ☐ DON'T KNOW

If YES, please explain why you reached this opinion: _____

_____

_____

_____

6. During your dives did water enter the mask at anytime? ☐ YES ☐ NO

If so, describe (how much water, location of entry, what caused it, did you have to surface, were you able to clear the mask): _____

_____

_____

_____

RATING CATEGORIES:

1. Extremely poor	4. Adequate
2. Poor	5. Very good
3. Not quite adequate	6. Excellent

7. Did you have problems clearing during your dive? ☐ YES ☐ NO

If YES, specify: _____

_____

_____

8. Did you experience any face squeeze? ☐ YES ☐ NO

If YES, specify: _____

_____

_____

9. Did any face mask fogging occur during the dive? ☐ YES ☐ NO

If so, explain: _____

_____

_____

10. Did the mask produce any visual distortion? ☐ YES ☐ NO

Comments: _____

_____

_____

11. How do you rate mask visibility? _____

Comments: _____

_____

_____ _____

_____

RATING CATEGORIES:

1. Extremely poor	4. Adequate
2. Poor	5. Very good
3. Not quite adequate	6. Excellent

12. Did you notice any muscular fatigue or strain in your jaws during your dive with the full face mask? ☐ YES ☐ NO

If YES, how long into the dive did it first begin? _____

_____

_____

13. In general, how would you rate the performance of the mask? _____

Comments: _____

_____

14. What suggestions do you have for improving the mask? _____

_____

_____

_____

_____

_____

_____

_____

15. Did you wear a hood on this dive? ☐ YES ☐ NO

If NO, you have completed this form.

If YES:

a. What type of hood was it?

☐ Wet Suit
☐ Dry Suit
☐ Other (specify: _____)

b. Did the mask give adequate seal around hood with no water leakage?

☐ YES
☐ NO

If NO, you have any suggestions for improvement of the seal? _____

_____

_____

c. Were there any other problems with the mask involving your hood (i.e. air leaks into hood, spider band too tight, mouthpiece, etc.)?

☐ YES
☐ NO

If YES, specify: _____

_____

_____

ANNEX B

FINAL DIVE QUESTIONNAIRE

NAME: _____ DATE: _____

List total number of dives you have made with each mask:

1. British Full Face Mask #_____
2. Parkway Full Face Mask #_____
3. Birns Full Face Mask #_____

RATING CATEGORIES:

1. Extremely poor
2. Poor
3. Not quite adequate
4. Adequate
5. Very good
6. Excellent

Based on your experience with these masks, please rate the overall performance of each:

1. British Full Face Mask _____
2. Parkway Full Face Mask _____
3. Birns Full Face Mask _____

Rank the masks in order of preference (1 indicates the one most preferred and 3 indicates the one least preferred):

1. British Full Face Mask _____
2. Parkway Full Face Mask _____
3. Birns Full Face Mask _____

What feature(s) of the mask selected as #1 caused you to rank it first?

_____

_____

What feature(s) of the mask selected as #3 caused you to rank it last?

_____

_____

ANNEX C

UNDERWATER VISUAL PERIMETRY

PURPOSE

This test provides a measure of the amount of peripheral vision permitted by a diving mask or helmet in an underwater setting.

APPARATUS DESCRIPTION

NEDU's underwater visual perimetry apparatus consists of a 180° arc, 39 inches in diameter, mounted on a support frame. The midpoint of the arc is attached to a rotating sleeve which allows the arc to be moved in 30° increments around a horizontal axis. A small white pointer designed to project approximately one inch above the edge of the arc is used as the target. It has a small slot which is positioned to slide along the bottom edge of the arc, maintaining a constant pointer height. A photograph of the underwater visual perimetry device is shown on page C-4.

TEST POOL REQUIREMENTS

The water in the test pool must be completely clear when conducting a visual perimetry experiment. This is absolutely essential to the collection of standardized visual field measurements. If the pool has been recently filled, it is usually necessary to wait for several days before the required water clarity is achieved. The temperature of the water is less critical. The diver must, however, be dressed appropriately for the water temperature since it is difficult to obtain consistent visual threshold measurements from a cold or shivering diver. Also, diver signals may need to be modified if cold water gear is being worn.

PERSONNEL REQUIREMENTS

A minimum of six diver-subjects should be used for these measurements. Divers should have normal uncorrected vision with no astigmatism. They should be selected to represent a range of face sizes and contours to ensure that the information collected can be generalized to the overall population.

Once in position at the bottom of the test pool, the apparatus can be operated and measurements taken by a single experimenter. If the measurements are being taken in cold water, however, additional experimenters may be needed to reduce the exposure time of individual experimenters.

SETUP PROCEDURES

The arc is placed in the horizontal plane and the diver is positioned so that the eyes lie on an imaginary line connecting the two 90° points at each end of the arc. A rubber-tipped support rod, which extends along the center axis of the plane of the arc from the midpoint, is then adjusted to rest against the helmet or mask faceplate. A vertical support brace is then raised into position under the edge of the helmet or the diver's chin to provide additional support. Thus, the diver is stabilized both horizontally and vertically in the perimetry device and this head position is maintained throughout the testing session. The diver can lean against the vertical support and grasp its horizontal attachment bar with one hand to further stabilize position.

TESTING PROCEDURES

The diver's visual perimeter is measured using the "method of limits." The diver is instructed to keep both eyes open and focused straight ahead while the measurements are being taken. Beginning near the center of the perimeter arc where the diver can clearly see it, the target pointer is slowly moved away from the midpoint along the outside edge of the arc towards its end and the diver signals when the pointer departs from view. If the pointer is moved too rapidly, the accuracy of the measurements will be decreased. The pointer is then moved from a position near the end of the arc back toward its midpoint until the diver signals that it has reentered the field of view. The experimenter should start at varying distances beyond the diver's visual periphery with this second pass, so that the diver will not develop expectations for how long it will take for the pointer to reappear, since these expectations could influence the measurements given. These ascending and descending limit measures are recorded and later averaged to produce the diver's perimetry measure for that angular position. Since the arc is marked in 5° increments, the measurement recorded may require some interpolation by the experimenter.

To begin the measurements, the arc is placed in the horizontal plane and the first measurement is taken on the diver's right side at 0° and then on the left side at 180°. The process is repeated, rotating the arc counterclockwise with respect to the diver-subject. Measurements are taken at 30° increments until the entire 360° perimeter has been completed. Following the measurements at 90° and 270°, the arc is repositioned so that the pointer will always be positioned above the top edge of the arc.

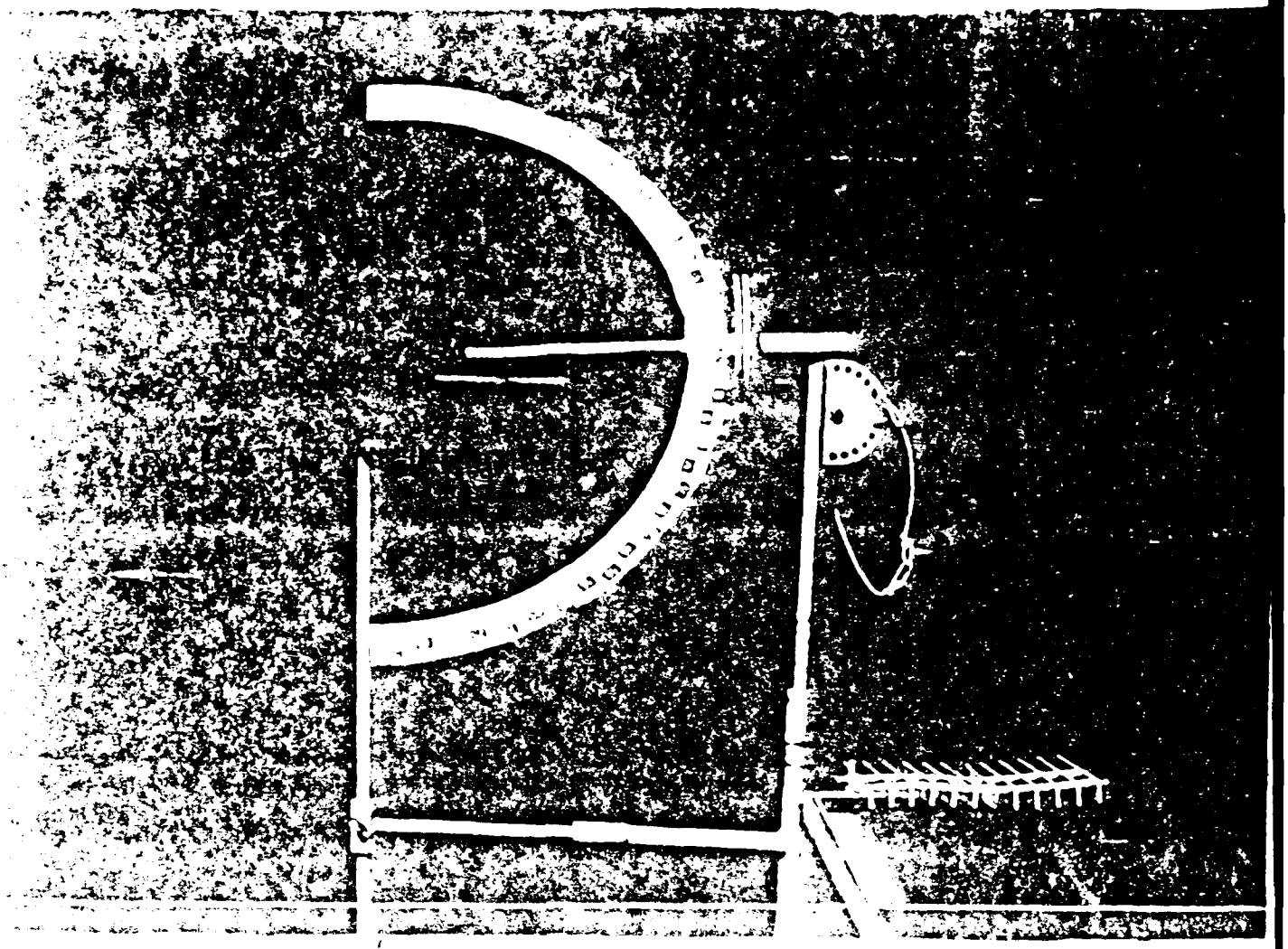
Three masks are to be evaluated, it is important that their order of use by the divers be counterbalanced. This means that the order in which the masks are tested should be different for each diver. Once all possible order sequences have been used, the sequences should be repeated until all divers have been tested. This ensures that any change in diver performance on this test over repeated trials due to increased familiarity with the task will not be confounded with mask type.

DATA RECORDING

An example of a data sheet is given on page C-5. The experimenter records each measurement with a soft lead pencil using a data sheet duplicated on "Kimdura" paper (Munising, Carson, CA). This paper is especially formulated for use underwater. A supply of these data sheets should be mounted on an underwater clipboard and attached to the small support shelf provided on the front of the perimetry device for the use of the experimenter.

DATA ANALYSIS

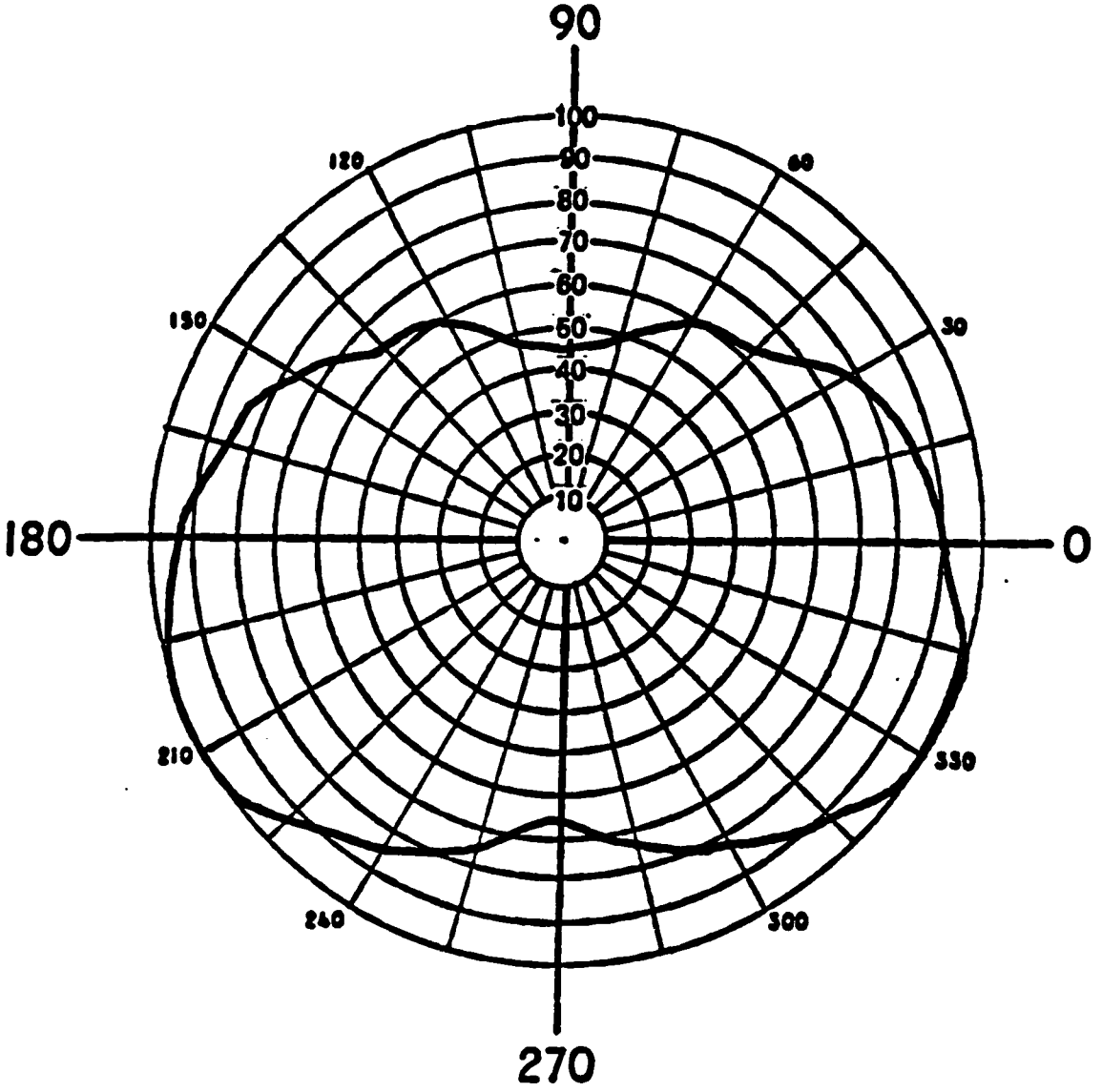
The limit of the visual perimeter for the mask is obtained for each diver by averaging the ascending and descending limits obtained for each angle. The individual perimeters are then averaged across all the divers included in the experiment. The results of the visual field evaluation should then be plotted on a standard visual field chart for comparison with the normal unrestricted binocular vision pattern. An example of this chart is provided on page C-6.



VISUAL PERIMETRY DATA SHEET

DATE: _____ DIVER: _____ MASK: _____

	TRIAL 1	TRIAL 2	AVERAGE
0°			
180°			
30°			
210°			
60°			
240°			
90°			
270°			
300°			
120°			
330°			
150°			


90
100
90
80
70
60
50
40
30
20
10
120
60
150
30
180
0
210
330
240
300
270

APPENDIX B

SCUBA FULL FACE MASK QUESTIONNAIRE

TYPE OF MASK USED: British FFM

NUMBER OF DIVES: 26

NUMBER OF SUBJECTS: 17

TYPE OF SUIT WORN: A. 15 Wet Suits
B. 6 Viking Dry Suits
C. 5 Swim Trunks

Number of Times Mask Used	Number of Divers
1	12
2	2
3	2
4	1

Did you wear gloves or mitts: YES (18) NO (8)

1. How do you rate the fasteners, fittings provided on the mask?

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (1)
4. Adequate (10)
5. Very good (14)
6. Excellent (0)

Missing Data (1)

How do you rate their ease of use?

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (1)
4. Adequate (10)
5. Very good (10)
6. Excellent (4)

Missing Data (1)

How do you rate their reliability?

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (0)
4. Adequate (9)
5. Very good (12)
6. Excellent (3)

Missing Data (2)

2. If you wore gloves or mitts, did you have problems using or adjusting any fasteners or fittings?

Yes (5)
No (10)
Not applicable (11 - includes several dry suit dives where the tenders made all adjustments for diver)

3. How do you rate the fit and comfort of the following?

a. Nose clip

Fit:

1. Extremely poor (2)
2. Poor (5)
3. Not quite adequate (2)
4. Adequate (8)
5. Very good (2)
6. Excellent (0)
Missing Data (7)

Comfort:

1. Extremely poor (3)
2. Poor (6)
3. Not quite adequate (2)
4. Adequate (3)
5. Very good (3)
6. Excellent (1)
Missing Data (8)

b. Face seal

Fit:

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (4)
4. Adequate (8)
5. Very good (9)
6. Excellent (4)
Missing Data (1)

Comfort:

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (0)
4. Adequate (9)
5. Very good (11)
6. Excellent (3)
Missing Data (3)

c. Spider or strap

Fit:

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (1)
4. Adequate (7)
5. Very good (15)
6. Excellent (2)
Missing Data (1)

Comfort:

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (1)
4. Adequate (6)
5. Very good (15)
6. Excellent (1)
Missing Data (3)

d. Mouthpiece

Fit:

1. Extremely poor (0)
2. Poor (1)
3. Not quite adequate (3)
4. Adequate (15)
5. Very good (4)
6. Excellent (1)

Missing Data (2)

Comfort:

1. Extremely poor (0)
2. Poor (2)
3. Not quite adequate (4)
4. Adequate (11)
5. Very good (4)
6. Excellent (1)

Missing Data (4)

4. What is the most uncomfortable aspect of diving this mask?

Mouthpiece (2)
Nose clip (9)
Visual distortion (7)
Water leak (3)
No comment (5)

5. In your opinion do you feel that you had better thermal protection than with a regular SCUBA face mask?

Yes (19)
Same (3)
No (0)
Don't know (4)

6. During your dives did water enter the mask at anytime?

Yes (7)
No (19)

7. Did you have problems clearing during your dive?

Yes (9)
No (17)

8. Did you experience any face squeeze?

Yes (1)
No (25)

9. Did any face mask fogging occur during the dive?

Yes (14)
No (12)

10. Did the mask produce any visual distortion?

Yes (17)
No (9)

11. How do you rate mask visibility?

1. Extremely poor (1)
2. Poor (2)
3. Not quite adequate (1)
4. Adequate (10)
5. Very good (8)
6. Excellent (4)

12. Did you notice any muscular fatigue or strain in your jaws during your dive with the full face mask?

Yes (3)
No (23)

13. In general, how would you rate the performance of the mask?

1. Extremely poor (0)
2. Poor (1)
3. Not quite adequate (4)
4. Adequate (11)
5. Very good (7)
6. Excellent (3)

14. Did you wear a hood on this dive?

Yes (7)
No (19)

If Yes:

a. What type of hood was it?

Wet Suit (1)
Dry Suit (6)

b. Did the mask give adequate seal around hood with no water leakage?

Yes (6)
No (1)

c. Were there any other problems with the mask involving your hood (i.e., air leaks into hood, spider band too tight, mouthpiece, etc.)?

Yes (2) - mouthpiece too flimsy
No (5)

TYPE OF MASK USED: Parkway Cressi Sub FFM

NUMBER OF DIVES: 24

NUMBER OF SUBJECTS: 18

TYPE OF SUIT WORN: A. 12 Wet Suits
B. 6 Viking Dry Suits
C. 6 Swim Trunks

Number of Times Mask Used	Number of Divers
1	13
2	4
3	1

Did you wear gloves or mitts: YES (16) NO (8)

1. How do you rate the fasteners, fittings provided on the mask?

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (2)
4. Adequate (16)
5. Very good (4)
6. Excellent (1)

Missing Data (1)

How do you rate their ease of use?

1. Extremely poor (0)
2. Poor (1)
3. Not quite adequate (1)
4. Adequate (16)
5. Very good (4)
6. Excellent (1)

Missing Data (1)

How do you rate their reliability?

1. Extremely poor (0)
2. Poor (1)
3. Not quite adequate (1)
4. Adequate (14)
5. Very good (6)
6. Excellent (0)

Missing Data (2)

2. If you wore gloves or mitts, did you have problems using or adjusting any fasteners or fittings?

Yes (10)
No (5)
Not applicable (9)

3. How do you rate the fit and comfort of the following?

a. Ear clearing device

Fit:

1. Extremely poor (0)
2. Poor (1)
3. Not quite adequate (3)
4. Adequate (7)
5. Very good (6)
6. Excellent (3)

Missing Data (4)

Comfort:

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (1)
4. Adequate (8)
5. Very good (8)
6. Excellent (3)
   Missing Data (4)

b. Face seal

Fit:

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (1)
4. Adequate (11)
5. Very good (7)
6. Excellent (5)

Comfort:

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (2)
4. Adequate (7)
5. Very good (10)
6. Excellent (5)

c. Spider or strap

Fit:

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (1)
4. Adequate (14)
5. Very good (6)
6. Excellent (3)

Comfort:

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (2)
4. Adequate (11)
5. Very good (8)
6. Excellent (3)

d. Mouthpiece

Fit:

1. Extremely poor (0)
2. Poor (3)
3. Not quite adequate (2)
4. Adequate (11)
5. Very good (6)
6. Excellent (2)

Comfort:

1. Extremely poor (0)
2. Poor (3)
3. Not quite adequate (6)
4. Adequate (8)
5. Very good (5)
6. Excellent (2)

4. What is the most uncomfortable aspect of diving this mask?

Mouthpiece (8)
Nose clip (3)
Straps over ear (3)
Mask fit (2)
No comment (8)

5. In your opinion do you feel that you had better thermal protection than with a regular SCUBA face mask?

Yes (16)
Same (4)
No (0)
Don't know (4)

6. During your dives did water enter the mask at anytime?

Yes (7)
No (17)

7. Did you have problems clearing during your dive?

Yes (4)
No (20)

8. Did you experience any face squeeze?

Yes (1)
No (23)

9. Did any face mask fogging occur during the dive?

Yes (10)
No (14)

10. Did the mask produce any visual distortion?

Yes (1)
No (23)

11. How do you rate mask visibility?

1. Extremely poor (0)
2. Poor (1)
3. Not quite adequate (0)
4. Adequate (8)
5. Very good (12)
6. Excellent (3)

12. Did you notice any muscular fatigue or strain in your jaws during your dive with the full face mask?

Yes (4)
No (20)

13. In general, how would you rate the performance of the mask?

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (2)
4. Adequate (6)
5. Very good (12)
6. Excellent (4)

14. Did you wear a hood on this dive?

Yes (10)
No (14)

If Yes:

a. What type of hood was it?

Wet Suit (4)
Dry Suit (6)

b. Did the mask give adequate seal around hood with no water leakage?

Yes (8)
No (2)

c. Were there any other problems with the mask involving your hood (i.e., air leaks into hood, spider band too tight, mouthpiece, etc.)?

Yes (0)
No (10)

TYPE OF MASK USED: Birns Oceanographics Ltd. U.S. Divers FFM

NUMBER OF DIVES: 26

NUMBER OF SUBJECTS: 18

TYPE OF SUIT WORN: A. 14 Wet Suits
B. 6 Viking Dry Suits
C. 6 Swim Trunks

Number of Times Mask Used	Number of Divers
1	13
2	3
3	1
4	1

Did you wear gloves or mitts: YES (19) NO (7)

1. How do you rate the fasteners, fittings provided on the mask?

1. Extremely poor (2)
2. Poor (5)
3. Not quite adequate (8)
4. Adequate (9)
5. Very good (1)
6. Excellent (0)

Missing Data (1)

How do you rate their ease of use?

1. Extremely poor (1)
2. Poor (3)
3. Not quite adequate (8)
4. Adequate (12)
5. Very good (1)
6. Excellent (0)

Missing Data (1)

How do you rate their reliability?

1. Extremely poor (0)
2. Poor (5)
3. Not quite adequate (6)
4. Adequate (13)
5. Very good (0)
6. Excellent (0)

Missing Data (2)

2. If you wore gloves or mitts, did you have problems using or adjusting any fasteners or fittings?

Yes (9)
No (8)
Not applicable (9)

3. How do you rate the fit and comfort of the following?

a. Ear clearing device

Fit:

1. Extremely poor (1)
2. Poor (4)
3. Not quite adequate (3)
4. Adequate (7)
5. Very good (4)
6. Excellent (0)

Missing Data (7)

Comfort:

1. Extremely poor (1)
2. Poor (5)
3. Not quite adequate (4)
4. Adequate (6)
5. Very good (3)
6. Excellent (0)
   Missing Data (7)

b. Face seal

Fit:

1. Extremely poor (2)
2. Poor (6)
3. Not quite adequate (8)
4. Adequate (9)
5. Very good (1)
6. Excellent (0)

Comfort:

1. Extremely poor (1)
2. Poor (4)
3. Not quite adequate (6)
4. Adequate (14)
5. Very good (1)
6. Excellent (0)

c. Spider or strap

Fit:

1. Extremely poor (2)
2. Poor (4)
3. Not quite adequate (8)
4. Adequate (9)
5. Very good (2)
6. Excellent (1)

Comfort:

1. Extremely poor (2)
2. Poor (3)
3. Not quite adequate (5)
4. Adequate (13)
5. Very good (2)
6. Excellent (1)

d. Mouthpiece

Fit:

1. Extremely poor (3)
2. Poor (2)
3. Not quite adequate (2)
4. Adequate (7)
5. Very good (2)
6. Excellent (0)
   Missing Data (10)

Comfort:

1. Extremely poor (3)
2. Poor (2)
3. Not quite adequate (2)
4. Adequate (7)
5. Very good (2)
6. Excellent (0)
   Missing Data (10)

4. What is the most uncomfortable aspect of diving this mask?

Water in mouth area and constant free flow (11)
To prevent free flow tight straps causing jaw ache (5)
Inadequate seal (5)
No comment (5)

5. In your opinion do you feel that you had better thermal protection than with a regular SCUBA face mask?

Yes (13)
Same (7)
No (1)
Don't know (5)

6. During your dives did water enter the mask at anytime?

Yes (20)
No (6)

7. Did you have problems clearing during your dive?

Yes (8)
No (18)

8. Did you experience any face squeeze?

Yes (1)
No (25)

9. Did any face mask fogging occur during the dive?

Yes (11)
No (15)

10. Did the mask produce any visual distortion?

Yes (1)
No (25)

11. How do you rate mask visibility?

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (1)
4. Adequate (15)
5. Very good (8)
6. Excellent (2)

12. Did you notice any muscular fatigue or strain in your jaws during your dive with the full face mask?

Yes (7)
No (19)

13. In general, how would you rate the performance of the mask?

1. Extremely poor (2)
2. Poor (5)
3. Not quite adequate (11)
4. Adequate (8)
5. Very good (0)
6. Excellent (0)

14. Did you wear a hood on this dive?

Yes (10)
No (16)

If Yes:

a. What type of hood was it?

Wet Suit (4)
Dry Suit (6)

b. Did the mask give adequate seal around hood with no water leakage?

Yes (2)
No (8)

c. Were there any other problems with the mask involving your hood (i.e., air leaks into hood, spider band too tight, mouthpiece, etc.)?

Yes (4) - spider band too tight
No (5)
Missing Data (1)

FINAL DIVE QUESTIONNAIRE

TOTAL NUMBER OF DIVERS = 17

1. List total number of dives you have made with each mask

Number of Dives:	0	1	2	3	4	Unknown
a. British FFM	0	11	2	2	1	1
b. Parkway FFM	1	9	1	2	2	2
c. Birns FFM	0	10	2	2	1	2

2. Based on your experience with these masks, please rate the overall performance of the following:

a. British FFM

1. Extremely poor (0)
2. Poor (1)
3. Not quite adequate (4)
4. Adequate (5)
5. Very good (7)
6. Excellent (0)

b. Parkway FFM

1. Extremely poor (0)
2. Poor (0)
3. Not quite adequate (1)
4. Adequate (3)
5. Very good (8)
6. Excellent (4)

c. Birns FFM

1. Extremely poor (3)
2. Poor (5)
3. Not quite adequate (6)
4. Adequate (2)
5. Very good (1)
6. Excellent (0)

3. Rank the masks in order of preference (1 indicates the one most preferred and 3 indicates the one least preferred:

a. British FFM: 1. (5) 2. (10) 3. (2)

b. Parkway FFM: 1. (12) 2. (4) 3. (0)

c. Birns FFM: 1. (0) 2. (2) 3. (15)